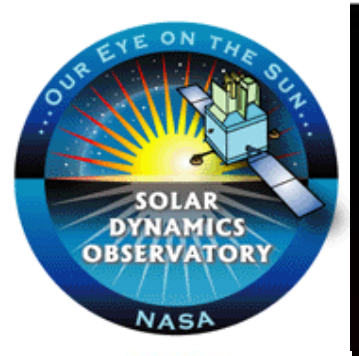
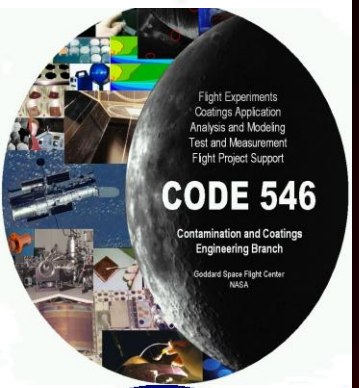
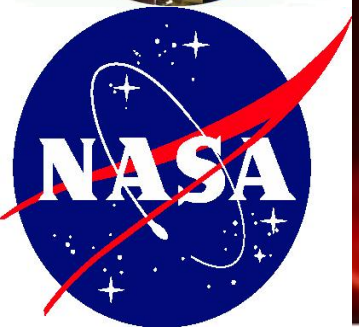




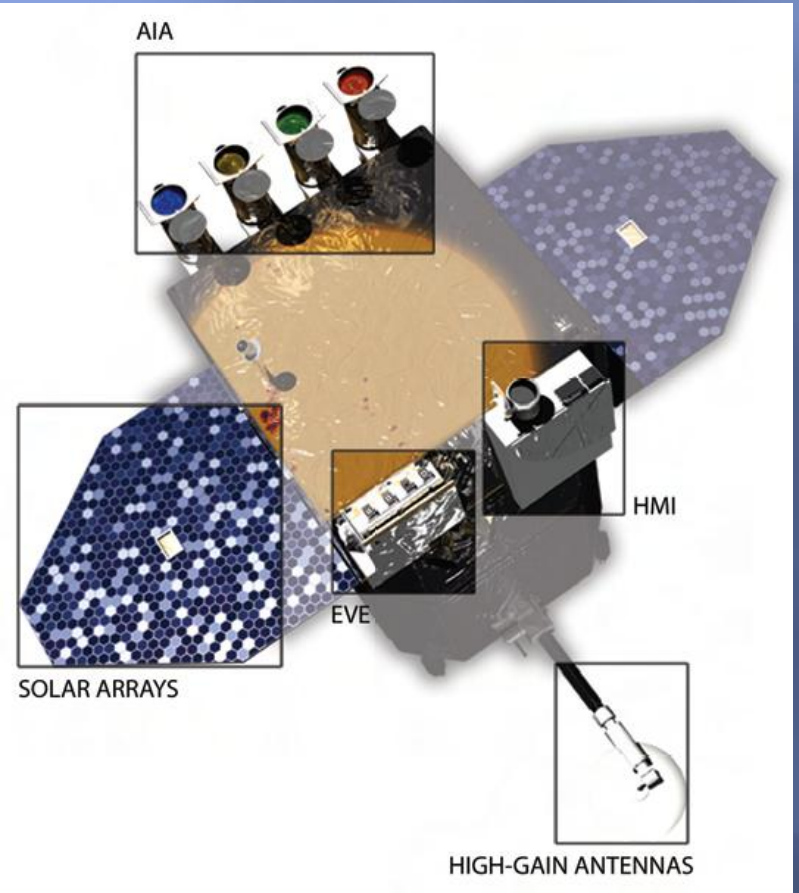


Solar Dynamics Observatory Lessons Learned

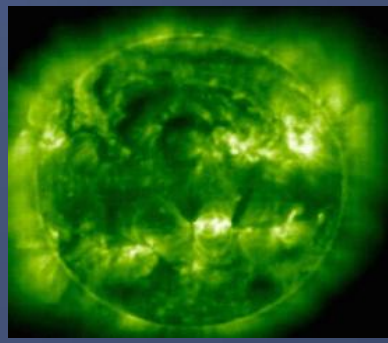
SPIE Conference San Diego, CA
August 4, 2010
Rachel Rivera/NASA GSFC
Mark Secunda/SGT
Drew Uhl/SGT

SDO Overview

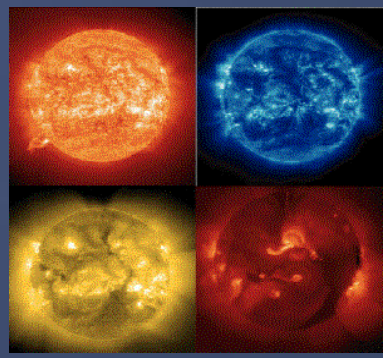
Mission is to study how solar activity is created and how space weather results from that activity.



- Atmospheric Imaging Assembly (AIA): High Resolution Images of 10 wavelengths every 10 seconds



- Extreme Ultraviolet Variability Experiment (EVE): Measure Sun's brightness in EUV.

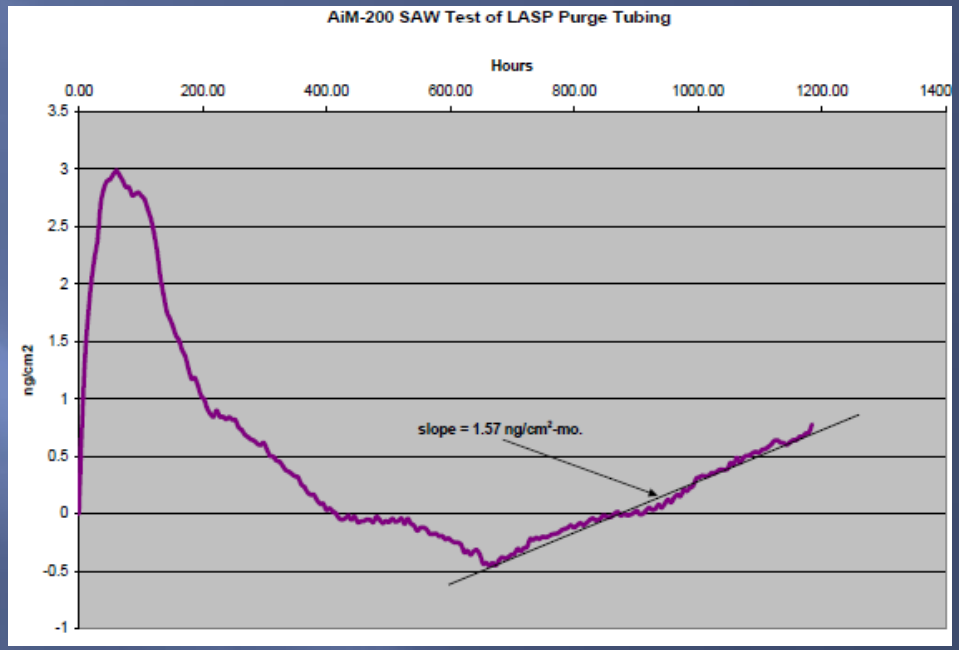


- Helioseismic and Magnetic Imager (HMI): Measures Doppler shift to study waves of the Sun.

- Launched February 11, 2010

Purge Tubing Monitoring

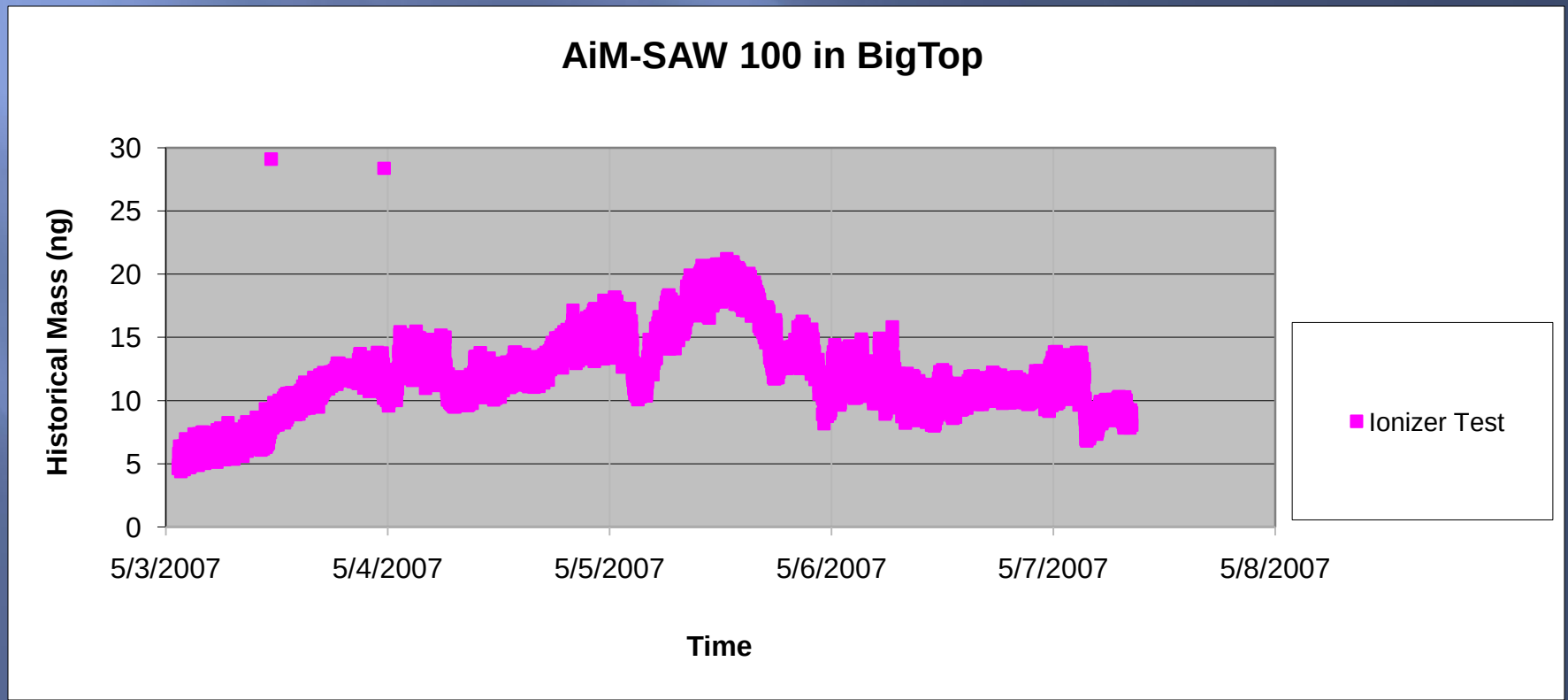
- EVE requirements stated as 3 ng/cm2-month.
- Used AiM-200 FT Surface Acoustic Wave (SAW) device to measure deposition.
- Old tubing (used for >1 year), was 1.75 ng/cm2-month



Material	Bake Out	NVR deposition
Chemfluor 367	No	129 ng/cm2-mo
PFA	No	52.4 ng/cm2-mo
PFA	baked @ 125C, 96 hrs	35.3 ng/cm2-mo
Chemfluor 367	baked @ 125C, 96 hrs	22.2 ng/cm2-mo

Ionizer Testing Prior to Use

- SDO ElectroStatic Discharge (ESD) requirement was Class 0 (sensitivity to < 250 Volts)
- Needed ionizers for many sensitive operations.
- Tested ionizer prior to cleanroom use.
- Ran ionizer for 4 days, measured NVR using an AiM-100 SAW
- Results show increase in NVR from room baseline after ionizer introduction
- Mandated 120 hours of run time for all new units prior to cleanroom use.



Bagging Material Study (Hypergols)

- SDO is sensitive to particle and molecular contamination.
- SDO must be bagged during all times outside a Class 10,000 environment.
- Many conflicting requirements.
  - Materials that are good for fueling are not good for EMI testing.
  - Materials with low contact transfer have poor ESD properties.
  - SDO was a Bi-Prop mission with Hypergolic Compatibility issues with Llumalloy

Type of Test	Standard	Screening Criterion
Electrostatic Discharge (ESD)	As per ASTM D257 or ANSI/EOS/ESD-S11.11-1993	Surface Resistivity: Between 10^5 and 10^{12} ohms/square (dissipative materials)
Non-Volatile Residue (NVR)	As per IEST-STD-CC1246D	Level A 1 mg/ 0.1 m^2
Particulate Cleanliness Levels	As per IEST-STD-CC1246D	Level 100
Outgassing: Total Mass Loss (TML)	ASTM E595	For low outgassing materials: TML<1.0 %
Outgassing: Collected Volatile Condensable Material (CVCM)	ASTM E595	For low outgassing materials: CVCM<0.1%
Hypergolic Compatibility	As per KSC report number MTB-175-88	Section 8: No significant reactivity observed as reported in KSC Form 3-539N.
Flammability	NASA-STD-6001	The material must meet the criteria of Test 1 (Upward Flame Propagation)
Static Decay	per MMA-1985-79	Triboelectric Method residual voltage after 5 seconds is not > 350 Volts

SDO Bagging Material Screening Criterion

1 mil (35% HSC)	**2 mil (35% HSC)**
Flammability: Passed	Flammability: Failed
Hypergolic: Side 1 : pass N_2O_4 Side 2: fail N_2O_4 Side 1 : fail N_2H_4 Side 2: pass N_2H_4 Side 1 : pass MMH Side 2: pass MMH	Hypergolic: Side 1 : pass N_2O_4 Side 2: pass N_2O_4 Side 1 : pass N_2H_4 Side 2: fail N_2H_4 Side 1 : pass MMH Side 2: pass MMH
Static Decay: passed	Static Decay: passed

Llumalloy Hypergolic Testing at KSC

Manufacturer/ Product Material Results/ Requirements	3M 1970 Static Shield	Caltex CP Stat 100	RCAS 4150	LF&P 8900C	KNF Film Orco-Ultra AN 109		Llumalloy (current material in circulation)	
ESD	Inner 9.65E+09 Outer 6.87E+09	Side A 1.83E+10 Side B 4.35E+10	Outer 1.1 X 10^9 Inner 3.2 X 10^9	Side A 4.08E+11 Side B 2.55E+11	Side A	Side B	Side A	Side B
					1.01E+13	7.93E+12	4.17E+14	3.14E+11
					2.02E+13	9.08E+12	5.99E+14	8.36E+11
					1.22E+13	8.04E+12	1.70E+15	1.07E+11
					1.88E+13	5.36E+12	5.36E+14	8.52E+11
					9.22E+12	7.16E+12	9.34E+15	3.62E+11
Particulate Cleanliness		Level 100	Suitable for Cleanrooms	Level 100				
Contact Transfer NVR	0.08 ug/cm^2	0.02 ug/cm^2	0.15 ug/cm^2	0.24 ug/cm^2	0.11 ug/cm^2		0.73 micrograms/cm2 10-day 0.17ug/cm^2 24 hour	
Extractable NVR	0.9 ug/cm^2	0.55 ug/cm^2	0.86 ug/cm^2	1.9 ug/cm^2	0.22 ug/cm2		0.03 micrograms/cm2 (to be re-tested)	
Outgassing	CVCM = 0.06% TML = 0.24%	CVCM = 0.02% TML = 0.19%	CVCM= 0.1% TML= 0.35%	CVCM= 0.19% TML = 0.39%	% CVCM = 0.33% %TML= 2.11%		CVCM= 0.00% TML=0.39%	
Flammability	Fail	Fail	Fail	Pass per KTI 5212C	Pass		Pass (1 mil)	
Static Decay	Pass	Pass	Pass	Pass per KTI 5212C	Pass		Pass (1 mil)	
Hypergolic Compatibility	Pass	Pass	Pass	Pass per KTI 5212C	Pass		Fail	

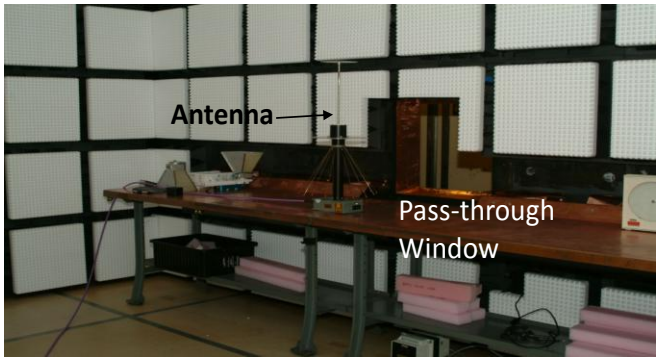
Bagging Material Study (EMI/EMC)

- EMI/EMC Testing can be a contamination risk to hardware due to particulate shedding from the room's foam
- The design of the room is optimized to meet cleanliness standards of Class 10k – Class 100 k
- Metallized bagging materials, such as Llumalloy, create Faraday Cages around the hardware and do not allow electromagnetic energy to pass through without attenuation
- An acceptable bagging material was needed for SDO that satisfied material selection criteria and was electromagnetically compatible

Bagging EMI/EMC Test Configuration

Llumalloy and two suitable bagging materials were tested for EMI/EMC in the smaller EMC lab of GSFC's Bldg.7

Bagging material was placed in a pass through between a transmitter and receiver in 2 separate rooms



- <3 dB signal attenuation response to frequency range 10 kHz to 30GHz
- 2 Acceptable Materials:

1- ATMI's Newform PE: *varied ESD properties lot-to-lot

2- Dupont's Melinex 1311

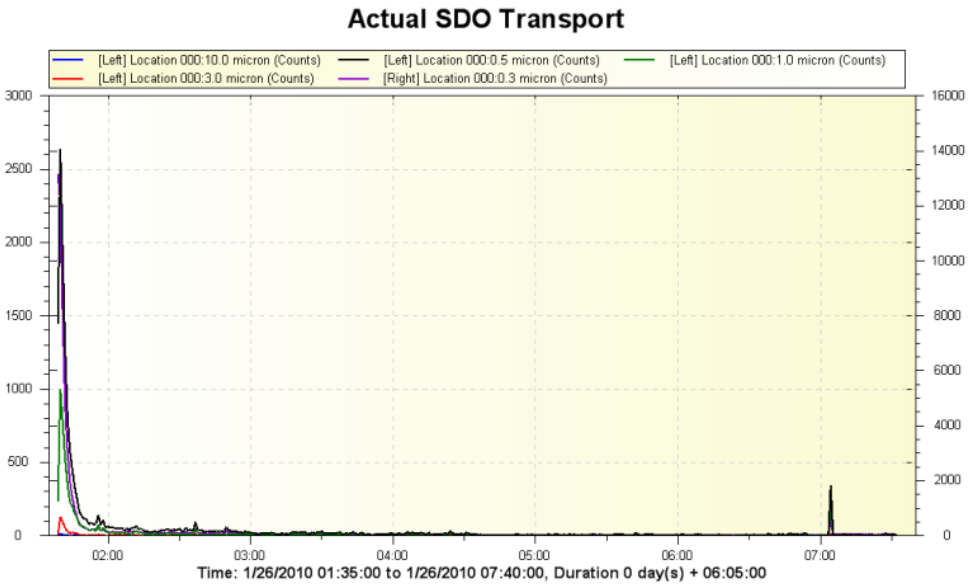
Dupont's Mellinex 1311: Static Dissipative, Cleanliness Level 0, NVR Contact Transfer Level A/10 and Rinse <Level A, Outgassing TML 0.26% and CVCM 0.00%
*Special Handling Procedures to maintain ESD properties

Atlas V Operations Cleanliness Monitoring

- New rocket, new environment.
- SDO slated to be first Atlas V NASA/Goddard mission.
  - Due to management priorities, LRO ended up being first, but much coordination between programs resulted in cost savings and good collaboration to explore environment.
- Needed to know processing environment
  - Encapsulation
  - Transport to Vertical Integration Facility (VIF)
  - Hoist to top of rocket at the VIF
  - VIF operations
- Developed strategy early on in program
  - Real-time measurements of particles with Particle Counter
  - Measure particles with fallout plates when possible
  - Real-time measurements of NVR with SAW
  - Measure NVR with witness plates.
- Difficult requirements to work around.
  - Issues with SAW not able to be worked out with Range Safety in time for use.
  - Real-time data for transport not available for SDO because of issues with RF energy limitations
- Still managed to get a good picture of environment.

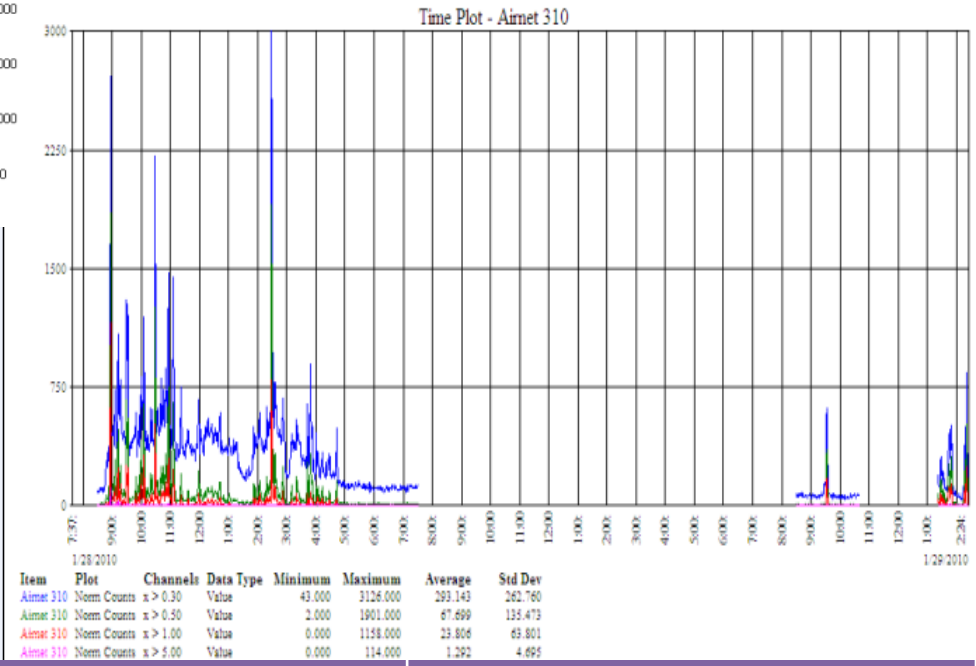
Launch Processing Activities

Atlas V 4 Meter Fairing Particle Counts



SDO transport from ASO to VIF

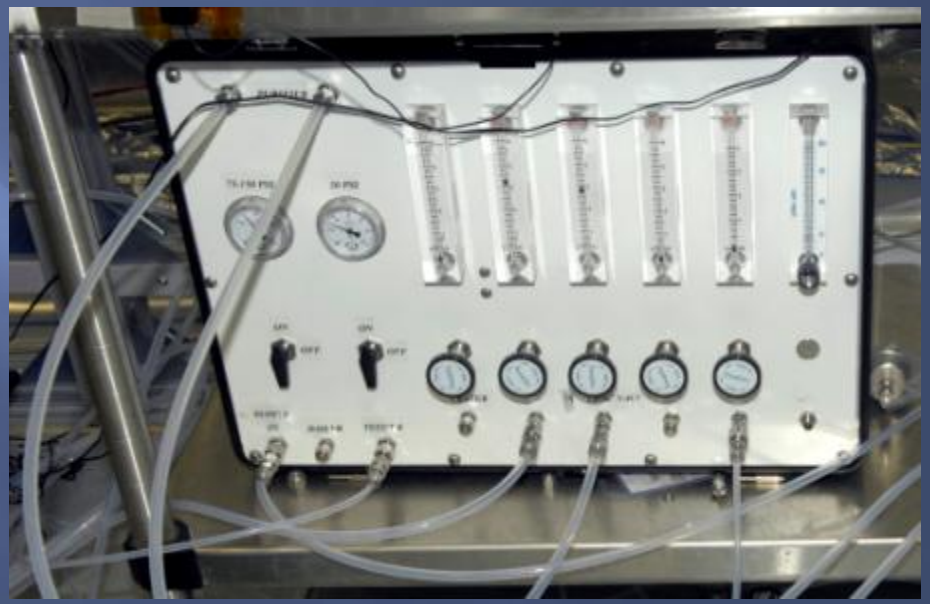
While at VIF



Exposure	Particles (2” silicone wafer)	NVR (12 in^2 plate)
Transport from Astrotech to the launch complex (7 days, 22 mi, 200 foot lift)	0.0048, 0.0044 PAC (~LVL 200)	0 mg/ft2 (blank same as or higher than test)
Launch complex operations to final fairing close-out (10 days)	0.025, 0.009 PAC (~LVL 200-300)	0 mg/ft2 (blank same as or higher than test)

Purge Systems

- Grade C Gaseous Nitrogen used to keep instruments clean and dry
- Purge Suitcase provided:
  - Different rates at different times
  - Filtration
  - Pressure Relief and Regulation
- Used 2 Purge Suitcases for leapfrogging
- Multiple dials used for early I&T led to confusion in later I&T
- Lack of clearly stated requirements also led to confusion
- 3 purge failures
  - Regulator failure at GSFC (SDO off line)
  - Shear failure of SSTL tubing during transport to FL
  - Purge not activated for rollout from VIF to pad
- Require tech to be on convoy
- Limit number of road trips



Purge Suitcase

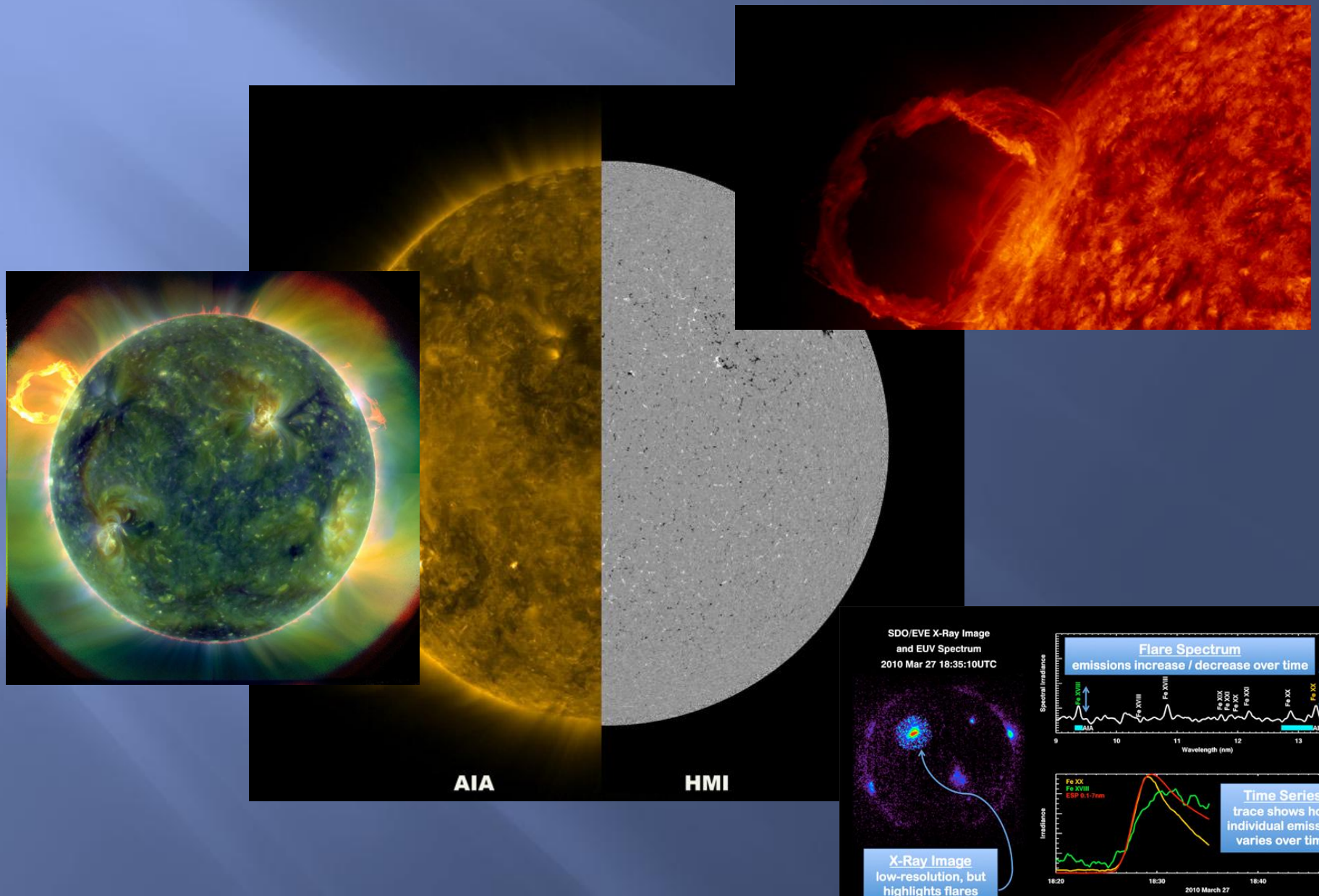
Laminar Flow Enclosure (LFE)

- SDO processed offsite of KSC at Astrotech.
- Using LFEs to make clean rooms into Class 10k cleanrooms were successful for STEREO and LRO; for SDO it did clean the room more so than without it, but not without issues
- In one incident, flow fields showed dramatic non-unidirectional flow
- Fans are loud
  - Safety issue especially during lifts – ended up turning off the LFE for lifts.
- Fans produced a major amount of heat
  - Led to trade-offs between cleanliness and thermal red limits of Observatory
  - Challenged the room's cooling ability
- 1 second power glitch will shut them down, need manual restart
- Tweaked fans and HVAC outlets to optimize flow and temperature
- Difference in room size/configuration may make major difference in acceptability
- Get a real cleanroom if possible
- Check flow field

One Liners

- Pens with SDO logo ended parade of unacceptable pens in the cleanroom, and made good swag
- Supposedly clean calrods weren't. Check 'em.

It Works!


AIA
HMI
SDO/EVE X-Ray Image
and EUV Spectrum
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X-Ray Image
low-resolution, but
highlights flares
Flare Spectrum
emissions increase / decrease over time
Spectral Irradiance
Wavelength (nm)
Time Series
trace shows how
individual emission
varies over time
Irradiance
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QUESTIONS?